Interference Considerations Involving The “Big LEO” Mobile Satellite Service Ancillary Terrestrial Component, The Broadcast Auxiliary Service, And Verizon’s Proposal for Relocating MDS Operations To The 2490–2500 MHz Band

Prepared For

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Introduction

Kessler and Gehman Associates, Inc. ("KGA") has been retained on behalf of the Wireless Communications Association International, Inc. ("WCA") to analyze technical issues associated with a proposal filed by Verizon Wireless ("Verizon") suggesting the relocation of Multipoint Distribution Service ("MDS") MDS channels 1 and 2/2A from the 2150-2162 MHz band to the 2490–2500 MHz band.[1] For the reasons set forth below, KGA respectfully submits that the proposal advanced by Verizon is fraught with difficulties, and adoption by the Commission could result in significant interference between relocated MDS operations and the operations of any neighboring Mobile Satellite Service Ancillary Terrestrial Component ("MSS/ATC") or Broadcast Auxiliary Service ("BAS") electronic news gathering ("ENG") facilities.

Background

KGA is a professional engineering firm, specializing in the design and evaluation of telecommunications systems for more than 40 years. The firm has been involved in virtually every phase of TV and FM broadcast, microwave communications, fiber optic, cable TV and wireless cable (MDS/ITFS), satellite earth stations, and two-way radio communications systems. The services rendered by KGA have ranged from consulting services on a daily basis to studies of technical and economic feasibility and the design and construction follow-up of major telecommunications systems in widely diverse geographical areas. In particular the firm has had extensive experience in the design of systems in geographical areas where special attention has had to be devoted to effects of meteorological variations on system propagation reliability. Baseband information carried on communications systems designed by the firm includes video, data, telemetry, supervisory, wide bandwidth audio, and telephone either in combination or individually.

The qualifications of the firm's key technical personnel are a matter of record with the Federal Communications Commission. KGA has represented many clients before the FCC in a variety of matters, including rule making and waiver requests of the Commission's rules to accommodate specialized telecommunications systems. While the firm maintains a continuous dialogue with equipment suppliers, contractors and manufacturers of television, radio and telecommunications equipment, its relationship to such companies is limited solely to the contacts necessary for the planning and implementation of systems for the firm's clients. The firm engages only in providing consulting services to its clients, and is thus not involved in the promotion, manufacture, sale or installation of any equipment. KGA or its personnel are members of the Wireless Cable Communications International, Inc. ("WCA"), the Association of Federal Communications Consulting Engineers ("AFCCE"), and the Institute of Electrical and Electronic Engineers ("IEEE").

[1] Reply Comments of Verizon Wireless, ET Docket No. 00-258 (filed April 28, 2003), submitted as an attachment to Letter from John T. Scott, III, Vice President & Deputy General Counsel, Verizon Wireless, IB Docket No. 02-364 (filed July 7, 2003).

Verizon's Proposal Would Leave Inadequate Spectrum For Licensees of MDS Channels 1 and 2

At present, MDS 1 is allocated the 2150-2156 MHz band, while MDS 2 is allocated to the 2156-2162 MHz band in 50 large markets. Aside from the destructive interference issues that are identified below in this report, Verizon's proposal for relocating MDS to the 2490-2500 MHz band provides inadequate spectrum for relocation of existing operations in markets where MDS licensees are utilizing all 12 MHz of the 2150-2162 MHz band to provide digital high speed Internet services – services that cannot viably be offered over less spectrum.

Verizon's Proposal Would Result In Destructive Interference Among MDS, BAS And MSS/ATC

Interference Analysis Methodology

The methodology used in this report to analyze the potential adverse consequences of Verizon's proposed 2490–2500 MHz band reallocation is to calculate the impact of brute force overload ("BFO") and Out of Band Emissions ("OOBE") levels from and to adjacent services. Unacceptable levels of BFO will result in an inoperable station when the victim receiver is in close proximity to an interfering station. Unacceptable OOBE levels will result in degraded receiver performance, which equates to reduced coverage areas, dropped calls or sessions, the inability to make calls or establish connections, and overall system performance degradation. The impact of BFO and OOBE can be minimized or eliminated by physical separation between a victim receiver and an interfering transmitter although, as discussed below, the required separation distance cannot always be achieved in a practical manner in the real world.

The impact of BFO and OOBE levels will be evaluated by calculating the required physical separation distance between a victim receiver and an interfering transmitter in order to give a measurable impact to system performance. Brute force overload occurs when a receiver reaches saturation from an overwhelming signal, which it is unable to reject. For purposes of this analysis, OOBE interference occurs when a victim receiver's noise floor is degraded by more than 1 dB from an interfering transmitter. The 1 dB degradation criteria was chosen because this represents a significant reduction in the potential coverage area of a communications system. In order to avoid a 1-dB degradation of the noise floor, the interfering signal must be at least 5.9 dB below the existing noise floor.

Although Verizon does not address where MSS/ATC, which is currently at 2492.5-2498 MHz will operate if MDS is relocated to 2490-2500 MHz, it is assumed for purposes of this analysis that Verizon would relocate MSS/ATC to 5.5 MHz of spectrum immediately below 2490 MHz.[2] Thus, it is assumed that relocated MDS would be adjacent to the Big LEO

[2] Although not addressed by Verizon, placement of MDS at 2490-2500 MHz would presumably require relocation of Big LEO MSS/ATC from 2492.5-2498 MHz to spectrum within 2483.5-2490 MHz. Although it is beyond the scope of this statement to examine that relocation in detail, it should be noted that the Commission specifically limited Big LEO MSS/ATC operations to the 2492.5-2498 MHz band to avoid interference with BAS and with unlicensed operations. Verizon has not addressed how the concerns that led the Commission to limit Big LEO

MSS/ATC frequencies assigned for base-to-subscriber transmissions ("downstream") under the Commission's forward band requirement. At present, MDS may be used for subscriber-to-base transmissions ("upstream") in conjunction with FDD two-way communications or for TDD service (which uses the same spectrum for downstream and upstream transmissions). In addition, Verizon's proposed MDS spectrum would also be separated by only 6.5 MHz from BAS channel A9 (2467-2483.5 MHz), which is typically used by high power mobile units that transmit to one or more established central receiving sites.

Interference Between MSS/ATC And MDS Facilities

Out of Band Emissions - MSS/ATC Downstream to MDS Upstream

Section 25.254(a)(4) of the FCC's rules specifies that an MSS/ATC licensee maintain its OOBE to a maximum allowable OOBE EIRP of -44.1 dBW/30 kHz at the edge of the MSS/ATC licensee's authorized frequency assignment. An EIRP of -44.1 dBW/30 kHz is the equivalent of -21.09 dBW normalized to a 6 MHz bandwidth. The noise level in a 6 MHz bandwidth is [-204 + $10\mathrm{Log}_{10}$(6,000,000)] –136.22 dBW. The protection required to avoid a 1-dB increase in the noise floor of an MDS receiver with a 5-dB noise figure is [-136.22 dBW + 5dB – 5.9 dB] –137.12 dBW/6 MHz. Therefore, based on the following calculations and as illustrated by Figure 1, MSS/ATC would cause interference to any MDS station relocated under the Verizon proposal if the MDS station were located within 43.0 km (26.7 miles) of the MSS/ATC base station.[3] Given that MDS licensees are today using MDS channels 1 and 2/2A to serve the same urban and suburban markets MSS/ATC appears to be targeting, and both will be using cellular network architectures, such separations distances cannot be maintained as a practical matter.

Distance Separation = Antilog [(EIRP/1 MHz + Receiving Antenna Gain – Noise Floor Protection – 104.5)/20]
= Antilog [(-21.09 dBW + 17 dBi – -137.12 dBW – 104.5)/20]
= Antilog [(133.03 dB – 104.5)/20]
= 26.7 miles, or 43.0 km

MSS/ATC to 2492.5-2498 MHz can be satisfied if such operations are relocated closer to the BAS and unlicensed spectrum.

[3] For purposes of this analysis, it has been assumed that MSS/ATC and MDS would be immediately adjacent. Even if MSS/ATC were to be relocated to 2483.5-2489 MHz and a 1 MHz guardband established between the two services, the same distance separation would be required because the rules are silent on the allowable OOBE beyond the MSS/ATC channel edge and therefore the EIRP of –44.1 dBW/30 kHz would apply.

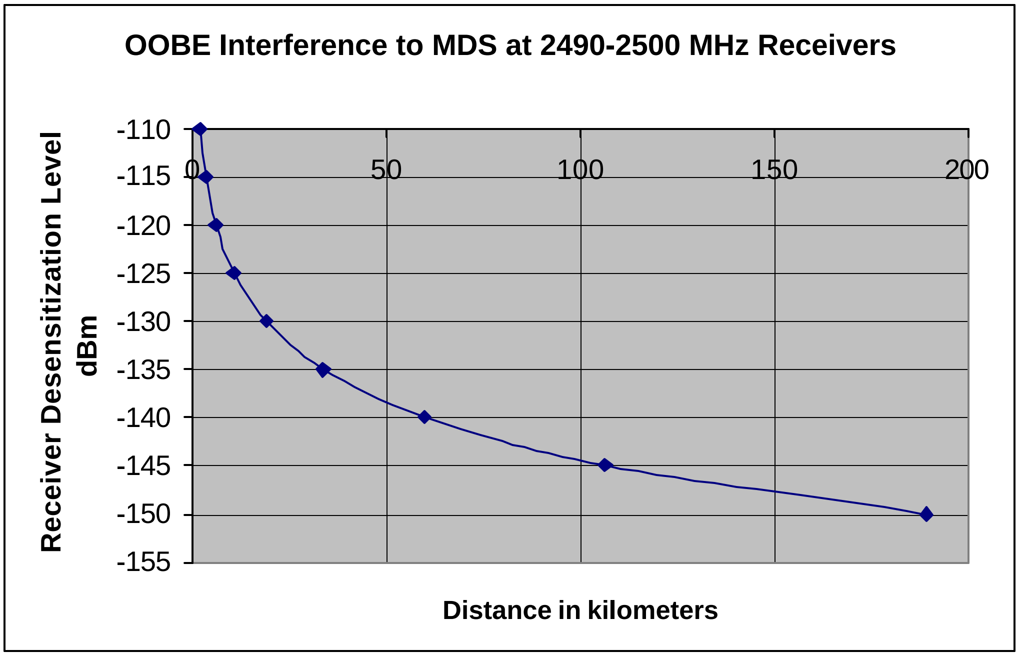


Figure 1. OOBE Interference – MSS/ATC to MDS at 2490-2500 MHz

Out of Band Emissions - MDS Downstream to MSS / ATC Downstream

Pursuant to Section 21.908 (d) of the FCC's rules, MDS out-of-band emissions for stations with EIRPs greater than –6 dBW must be attenuated 25 dBc at the channel edge, 40 dBc at 250 KHz and using a linear slope, to 60 dBc at 3 MHz from the channel edge. Although MDS operations are permitted up to 63 dBm EIRP, for the purposes of this engineering statement a more typical output power of 57 dBm (500 watts) EIRP is used to represent a more realistic deployment. MDS OOBE that fall in-band to the MSS/ATC subscriber equipment are expressed below in distance to the 1-dB desensitization of the victim subscriber receiver. Out of band emissions are normalized for a 1.23 MHz bandwidth consistent with IS-95 receiver bandwidths.

Separation from MDS Channel Edge	0 MHz	250 KHz	3 MHz
Bandwidth of MSS/ATC Handset (MHz)	1.23	1.23	1.23
Noise figure of MSS/ATC Handset (dB)	5.00	5.00	5.00
OOBE of MDS Base Station /1.23 MHz (dBm)	25.18	10.18	-9.88
Antenna Gain of MSS/ATC Handset (dB)	0.00	0.00	0.00
Effective Noise Power (dBm)*	25.18	10.18	-9.88
Frequency of ACLR interferer (MHz)	2490.00	2489.75	2487.00
KTB Rx Noise Floor (dBm)	-113.10	-113.10	-113.10
Rx Noise Floor (dBm)	-108.10	-108.10	-108.10
Attenuation required for 1 dB desensitization (dB)	139.28	124.28	104.22
Distance Separation - 1 dB desensitization (kilometers)	**88.00**	**15.65**	**1.56**
(miles)	**54.68**	**9.73**	**0.97**

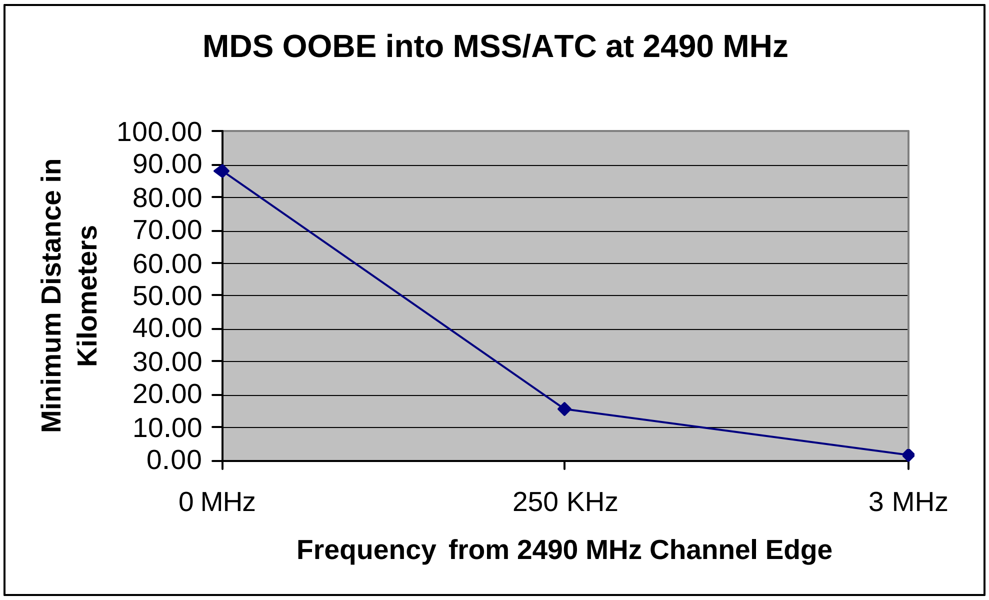


Figure 2. OOBE Interference – MDS to MSS/ATC at 2490 – 2487 MHz from an MDS Base Station Operating at 57 dBm EIRP *(not to scale)*

Based on the calculations above, Figure 2 illustrates the required separation distance in kilometers between MDS base stations and MSS/ATC subscriber equipment for operation with a 1-dB impairment to the noise floor. The calculations reveal without a doubt that MSS/ATC subscriber equipment will suffer destructive interference when within line of sight of and in near proximity to an MDS base station operating within the 3-MHz frequency separation required for MDS to achieve its 60 dBc OOBE attenuation. For example, at 2490 MHz which requires 88 Km line of sight separation, an MSS/ATC subscriber just 2 kilometers from an MDS base station, which is a reasonable distance for line of sight to occur, would receive out of band emissions 31.8 dB above its noise floor and be completely desensitized and non operational.

KTB Noise Floor = [-113.1 dBm] - [25.18 dBm EIRP/1.23 MHz – 106.5 dB FSL]

The same MSS/ATC subscriber equipment operating at 2489.75, which requires 15.65-km line of sight separation would, using the 2 km example, also receive out of band emissions from MDS 17.1 dB above its noise floor.

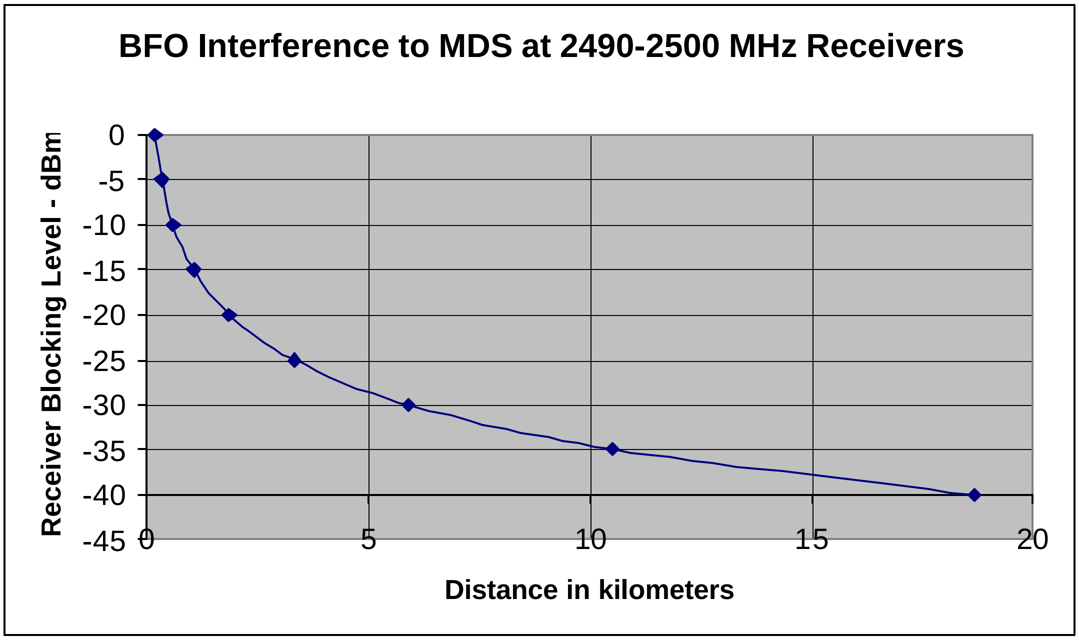
KTB Noise Floor = [-113.1 dBm] - [10.18 dBm EIRP/1.23 MHz – 106.5 dB FSL]

From the above examples, MDS and MSS/ATC cannot operate adjacent to each other at 2490 MHz in the same geographic area.

Brute Force Overload - MSS/ATC Downstream to MDS Upstream

BFO occurs when a receiver is saturated by an overwhelming signal it is unable to reject. For comparative purposes, the IS-95 standard for receiver blocking level is -30 dBm. Typical high quality LNA's used in MDS base stations can tolerate -28 dBm (-58 dBW) before the 1 dB compression point is reached causing BFO. The parameters of an IS-95 base station are set forth in Appendix C3 of the MSS/ATC report, which allows an EIRP of 32 dBW/1.25 MHz. MDS stations are licensed to use 6 MHz channels, so the equivalent EIRP in a 6 MHz channel is 38.81 dBW and the typical receiving antenna used by MDS is 17 dBi. Therefore, based on the following calculations and as illustrated by Figure 3, MSS/ATC base stations will cause BFO interference to the reception of upstream signals at MDS base stations located within 4.7 km (2.9 miles). Since MDS is operating in the same urban and suburban areas that MSS/ATC is apparently targeting and both services will be utilizing cellularized networks, the possibility of destructive interference clearly exists since as a practical matter MDS base stations will have to be deployed within 2.9 miles of MSS/ATC base stations in order to provide ubiquious coverage.

Distance Separation = Antilog [(EIRP/6 MHz + Receiving Antenna Gain – Blocking Level – 104.5)/20]
= Antilog [(38.81 dBW + 17 dBi – -58 dBW – 104.5)/20]
= Antilog [(113.81 dB – 104.5)/20]
= 2.92 miles, or 4.7 km



Figure

Figure 3. Brute Force Overload – MSS/ATC to MDS at 2490-2500 MHz

Figure 3 reflects the distance required between an MSS/ATC base station engaged in base to subscriber transmissions and an MDS response station hub (base station) receiving subscriber to base transmissions with a range of receiver blocking levels.

Brute Force Overload - MDS Downstream to MSS/ATC Downstream

The impact of BFO is less significant in this case since the MSS/ATC subscriber equipment will be completely desensitized and inoperative long before proximity to BFO is realized. MDS stations are licensed to use 6 MHz channels, and the typical IS-95 receiving antenna gain is 0 dBi. The IS-95 standard for receiver blocking level is -30 dBm. The parameters of a typical MDS base station operating at an EIRP of 27 dBW/6 MHz are corrected to the IS-95 receiver bandwidth of 1.23 MHz result in a EIRP of 20.1 dBW/1.23 MHz. Therefore, as shown by the following calculations, MDS will cause BFO interference to an MSS/ATC subscriber receiver at 97 meters or 318 feet.

Distance Separation = Antilog [(EIRP/1.23 MHz + Receiving Antenna Gain – Blocking Level – 104.5)/20]
= Antilog [(20.1 dBW + 0 dBi – -60 dBW – 104.5)/20]
= Antilog [(80.1 dB – 104.5)/20]
= .0603 miles, 318 feet or 97 meters

Interference Between MDS And BAS / ENG Mobile Facilities

To cover news, traffic, weather, cultural, and sporting events throughout a market area, ENG mobile facilities routinely setup at temporary, ever-changing locations within their licensed area of operation to broadcast live reports back to the broadcaster's studio. These mobile facilities are typically configured with 10-12 watt transmitters, which are mounted on a telescoping mast to eliminate feed-line loss. The gain of transmitting antennas used on mobile units depends on the type of mobile unit (vehicle in motion, vehicle parked, or portable tripod) and the distance between the mobile unit and the R/O site, but the gain ranges from 13 dBi to 25 dBi, with a typical unit using a 20-dBi gain and a beamwidth of about 12 degrees. ET Docket No 01-75 R&O part 74.636 limits the transmitter power output to 12 watts and the EIRP to a maximum of 35 dBW (3,162 watts) for BAS mobile operations emanating from the ENG facilities[4]. The resulting signal power from the ENG facility is the equivalent of a high-powered downstream broadcast facility on wheels (or wings in the case of helicopters and blimps) with an ability to transmit from any location, in any direction, and at any time within a market.

BAS channel A9 is located at 2467–2483.5 MHz, only 6.5 MHz away from the 2490–2500 MHz band proposed by Verizon for MDS reallocation, so BAS/ENG facilities present a potential for interference to MDS by both A) brute force overload and B) desensitization to MDS base station operations in the 2490-2500 MHz band. In addition, MDS downstream facilities have the potential for desensitization of the BAS/ENG central receiving sites.

[4] As a point of reference, an EIRP of 35 dBW is 2dB (1.58 times) higher than the maximum allowable EIRP for a high-powered MDS broadcast facility.

Out of Band Emissions - BAS / ENG Upstream to MDS Upstream

Section 74.637(a)(1) of the FCC's rules requires that BAS transmitters adhere to the following:

> "(i) On any frequency removed from the assigned (center) frequency by more than 50% up to and including 100% of the authorized bandwidth: At least 25 dB in any 100 kHz reference bandwidth (BREF);
> (ii) On any frequency removed from the assigned (center) frequency by more than 100% up to and including 250% of the authorized bandwidth: At least 35 dB in any 100 kHz reference bandwidth;
> (iii) On any frequency removed from the assigned (center) frequency by more than 250% of the authorized bandwidth at least 43 + 10 Log10 (P mean in watts) or 80 dB, which ever is the lesser attenuation, in any 100 KHz reference bandwidth".

Thus, the maximum allowable OOBE radiated into MDS channels at 2490-2500 MHz from BAS channel A9 (2467-2483.5 MHz) would be 10 dBW (40 dBm) [5] and from BAS channel A8 (2450-2467 MHz) would be 0 dBW (30 dBm). In order to determine desensitization to an MDS base station engaged in subscriber-to-base upstream operations at 2490 MHz, the ENG mobile transmitter OOBE, TPO and antennae gain must be understood. As discussed above, the BAS mobile transmitter is typically directly connected to a 20-dBi-gain antenna, which would result in an OOB EIRP ranging from 35.79 dBm on BAS-channel A9 to 25.79 dBm on channel A8. An MDS base station engaged in subscriber-to-base operations under Verizon's proposed 2490–2500 MHz band would typically use a 17-dBi gain antenna.

Based on these data, the attenuations required to protect the MDS base station noise floor against a 1-dB degradation are shown by the following calculations. These calculations are based on a channel A9 station with an OOB EIRP of 5.79 dBW in the 16.5 MHz bandwidth allocated to A9, which is equal to 1.40 dBW in a 6 MHz MDS channel.

Distance Separation = Antilog [(EIRP/6 MHz + Receiving Antenna Gain – Noise Floor Protection/1 MHz – 104.5)/20]
= Antilog [(1.40 dBW + 17 dBi – -137.12 dBW – 104.5)/20]
= Antilog [(155.52 dB – 104.5)/20]
= 355 miles, or 570 km

[5] For example, an EIRP of 35 dBW could be created from a TPO of 12 watts (10.79 dBW) and an antenna gain of 24.21 dBi. A TPO of 10.79 dBW minus 25 dB OOB attenuation equals -14.21 dBW, plus a 24.21 dBi antenna gain equals an OOBE of 10 dBW (40 dBm) shown above. However, a more typical OOBE would be created from a TPO of 12 watts (10.79 dBW) and an antenna gain of 20.00 dBi such that a TPO of 10.79 dBW minus 25 dB OOB attenuation equals -14.21 dBW, plus a 20.00 dBi antenna gain equals an OOBE of 5.79 dBW (35.79 dBm).

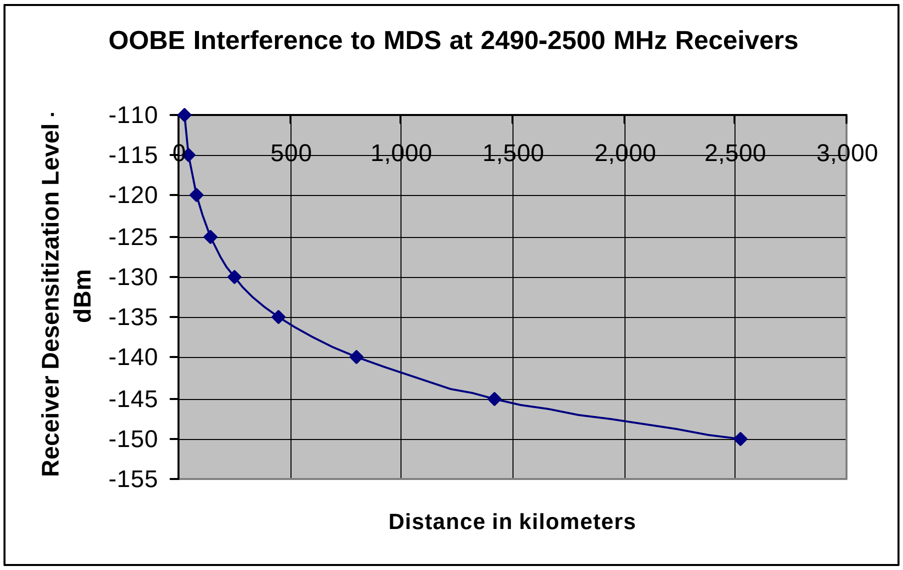


Figure 4. OOBE Interference – BAS to MDS at 2490-2500 MHz

Assuming the MDS subscriber to base station is within line of sight, the required distance between an ENG mobile unit transmitting in compliance with Section 74.637 and an MDS base station operating in Verizon's proposed 2490–2500 MHz band, ranges from 570 km on channel A9 and 180 km on channel A8. Because ENG units operate in the same geographic areas where MDS licensees are providing service, this sort of separation requirement cannot be met.

Out of Band Emissions - MDS Downstream to BAS / ENG Upstream

Using the same rationale for the MDS OOBE described in the MSS/ATC analysis above, MDS OOBE that would fall in-band to the BAS/ENG receiving equipment is expressed below as a function of the separation distance to avoid a 1-dB desensitization of the victim receiver. OOBE are normalized for a 17 MHz bandwidth consistent with BAS channel bandwidths.

Separation from MDS Channel Edge	3 MHz
Bandwidth of BAS / ENG Receiver (MHz)	17.0
Noise figure of BAS / ENG Reecive r (dB)	2.00
OOBE of MDS Base Station /17 MHz (dBm)	1.52
Antenna Gain of BAS / ENG Base Station (dBi)	20.00
Effective Noise Power (dBm)*	21.52
Frequency of ACLR interferer (MHz)	2483.50
KTB Rx Noise Floor (dBm)	-101.70
Rx Noise Floor (dBm)	-99.70
Attenuation required for 1 dB desensitization (dB)	127.22
Distance Separation - 1 dB desensitization (kilometers)	**21.94**
(miles)	**13.63**

The calculations shown above represent the required separation distance in kilometers between MDS base stations and BAS/ENG central receiving equipment for operation with a 1-

dB impairment to the noise floor. The calculations reveal without a doubt that BAS/ENG reception equipment will suffer destructive interference when within line of sight of and within 13.63 miles of an MDS base station. Given that BAS/ENG receivers are typically located in the same sorts of markets MDS will be serving, it is clear that MDS cannot operate at 2490-2500 MHz in the same geographic area as BAS/ENG without causing substantial interference to BAS/ENG operations.

Brute Force Overload - BAS/ENG Upstream to MDS Downstream

As demonstrated by the calculations below, the required distance between an ENG mobile unit transmitting with an EIRP of 35 dBW on channel A9 and transmitting in the direction of an MDS base station operating under Verizon's proposed 2490–2500 MHz band and engaged in subscriber-to-base operations is 1.8 km. An EIRP of 35 dBW on BAS channel A9, which has a bandwidth of 16.5 MHz, is equivalent to an EIRP of 30.61 dBW in an MDS bandwidth of 6 MHz. Since the beamwidth of an ENG transmitting antenna is about 12 degrees wide, there would be a sector with a 0.38 km arc and a radius of 1.8 km within which interference would be caused to an area of almost 0.33 square kilometers. Since numerous MDS base stations would be located throughout the ENG market area, there is a clear and apparent threat of harmful interference from BAS/ENG transmissions to MDS base stations.

Distance Separation = Antilog [(EIRP/6 MHz + Receiving Antenna Gain – Noise Floor Protection – 104.5)/20]
= Antilog 30.61 dBW + 17 dBi – -58 dBW – 104.5)/20]
= Antilog [(105.61 dB – 104.5)/20]
= 1.1 miles, or 1.8 km

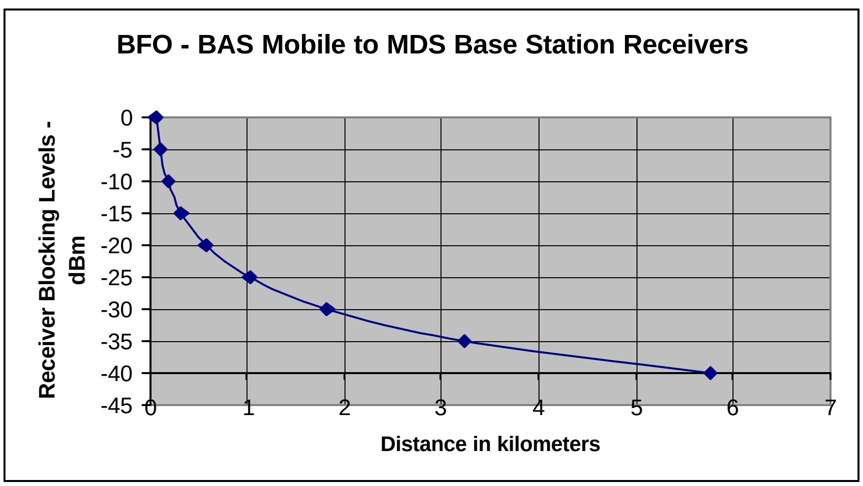


Figure 5. Brute Force Overload – BAS to MDS at 2490-2500 MHz.

Conclusions

In summary, MSS/ATC downstream base stations and MDS upstream services cannot coexist in adjacent channels as Verizon apparently contemplates. Moreover, BAS facilities located at 2450–2483.5 MHz are effectively mobile high power downstream operations that may operate anywhere at anytime in the ENG licensed areas, and coordination with MDS is impossible as a practical matter because MDS at 2490-2500 MHz would be utilized on a ubiquitous basis for subscriber-to-base station communications throughout the same service area. In addition, guard bands cannot be implemented to reduce the likelihood of interference because of the lack of sufficient spectrum in the 2483.5-2500 MHz band to provide separation among the BAS/ENG, MSS/ATC and MDS services that Verizon is attempting to squeeze into the band. For the reasons given above the 2490–2500 MHz band is not suited for MDS operations.

This engineering statement has been prepared by or under the direct supervision of Robert Gehman, Jr., who states under penalty of perjury that he is a professional engineer registered in the states of Florida, Maryland and Mississippi, he is president of Kessler and Gehman Associates, Inc., and the information contained in this statement is true and correct to the best of his knowledge and belief.

KESSLER AND GEHMAN ASSOCIATES, INC.

Robert Gehman, Jr., P.E.
President

July 21, 2003